# REPORT OF PERFORMANCE 1088-15

| | |
|---|---|
| **OBJECT** | Three-core heat-shrinkable outdoor termination |
| **TYPE** | GTM-OXAS-1233H6A ( GXO-13 )<br>6,35/11 (12) kV – 3x185 $mm^2$ – Al – XLPE |
| **CLIENT** | Gala Shrink Fit<br>Mumbai, India |
| **MANUFACTURER** | Gala Shrink Fi<br>Mumbai, India |
| **TESTED BY** | KEMA Nederland B.V.<br>Arnhem, The Netherlands |
| **DATE OF TESTS** | 12 August 2014 to 23 March 2015 |
| **TEST SPECIFICATION** | The programme was based on<br>IEC 60502-4 (2010), test sequence 1.1, 1.2, and 1.5. |
| **SUMMARY AND CONCLUSION** | The outdoor termination passed the electrical and non- electrical tests.<br>During the examination of the outdoor terminations after the salt fog test loss of dielectric quality due to tracking and/or erosion was found. |

This report applies only to the object tested. The responsibility for conformity of any object having the same type references as that tested rests with the manufacturer.

This report consists of 70 pages in total.



KEMA Nederland B.V.

S.A.M. Verhoeven
Director Testing, Inspections & Certification The Netherlands

Arnhem, 7 May 2015

Version: 1

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# 1 IDENTIFICATION OF THE OBJECT TESTED

## 1.1 Ratings/characteristics of the object tested and proved by tests

| | |
|---|---|
| Rated voltage, $U_0/U$ ($U_m$) | 6,35/11 (12) kV |
| Rated maximum conductor temperature in normal operation | 90 °C |
| Rated conductor cross-section | 3x185 $mm^2$ |
| Thermal short-circuit current | 22,5 kA |

## 1.2 Characteristics of the outdoor termination for cables with extruded insulation

| | |
|---|---|
| Manufacturer | Gala Shrink Fit, Mumbai, India |
| Type | heat-shrinkable outdoor termination |
| Type designation, reference number | GTM-OXAS-1233H6A ( GXO-13 ) |
| Year of manufacture | 2014 |
| Rated voltage, $U_0/U$ ($U_m$) | 6,35/11 (12) kV |
| No. of cores | 3 |
| Dynamic short-circuit current | not applicable |
| Creepage distance (minimum) | 750 mm, including sheds |
| Flashover distance (minimum) | 20 mm |
| Number of sheds | 2 |
| Material of insulating body | heat-shrinkable cross linked polyolefin anti-tracking material |
| Type of stress control | stress control mastic |

## 1.3 Characteristics of the test cable

Note: the cable is not part of the type test.

| | |
|---|---|
| Manufacturer (as stated by the client) | Apar Industries Limited, India |
| Type | $U_0$ = 6 kV 3x185 $mm^2$ Al/XLPE/CTS/PVC/SWA/PVC (A2XCEWY) CABLE |
| Manufacturing year | 2014 |
| Rated voltage, $U_0/U$ ($U_m$) | 6/10 (12) kV |
| No. of cores | 3 |
| Core identification | core 1 = red<br>core 2 = yellow<br>core 3 = blue |
| Marking on the oversheath | AIL/UNIT: UNIFLEX CABLES- INDIA 'UNICAB'<br>6/10 (12) KV XLPE CABLE '3X185 Sq.mm 2014 |
| Construction | see List of drawings |

**Conductor**

| | |
|---|---|
| – material | aluminium |
| – cross-section | 185 $mm^2$ |
| – nominal diameter | 16,2 mm |
| – type | stranded circular compacted |
| – maximum conductor temperature in normal operation | 90 °C |
| – presence and nature of measures to achieve longitudinal watertightness | no |

**Conductor screen**

| | |
|---|---|
| – material | extruded semi-conducting compound |
| – nominal thickness | 0,6 mm |
| – material designation | extruded semi-conducting compound |
| – manufacturer of the material | Hanwha and Sakun Polymer |

**Insulation**

| | |
|---|---|
| – material | XLPE |
| – nominal thickness | 3,4 mm |

**Insulation (core) screen**

| | |
|---|---|
| – material | extruded semi-conducting compound |
| – strippable | yes |
| – nominal thickness | 0,5 mm |

**Metal screen**

| | |
|---|---|
| – material | two annealed plain copper tape |
| – type | helical |
| – nominal thickness and width of tape | 0,03 x 40 mm (overlap 10%) |
| – nominal thickness and width of tape | 2 x 40 mm (overlap 10%) |
| – cross-sectional area | 27,6 $mm^2$ three cores together |

**Inner coverings and fillers**

| | |
|---|---|
| – material | yes |

**Separation sheath**

| | |
|---|---|
| – material | PVC, type $ST_2$ |
| – nominal thickness | 1,6 mm |
| – manufacturer of the material | Gala Shrink Fit, Mumbai, India |

**Metal armour**

| | |
|---|---|
| – material | galvanised steel round wires |
| – number of wires | 68 |
| – nominal diameter of wires | 2,5 mm |
| – cross-sectional area | 333,8 $mm^2$ |

| | |
|---|---|
| **Metal foil or tape, longitudinally applied, bonded to the oversheath** | no |

**Oversheath**

| | |
|---|---|
| – material | PVC, type $ST_2$ |
| – nominal thickness | 3,3 mm |
| – nominal overall diameter of the cable (D) | 72,0 mm |
| – material designation | PVC, type ST2 |
| – manufacturer of the material | Gala Shrink Fit, Mumbai, India |
| – colour | black |

**Manufacturing details insulation system**

| | |
|---|---|
| – location of manufacturing | Umbergaon, India |
| – type of extrusion line | CCV |
| – type of extrusion | triple common extrusion |
| – curing means | dry |
| – cooling means | dry |
| – manufacturing length (where cable sample for testing has been taken from) | 100 m |

## 1.4 List of drawings

The manufacturer has guaranteed that the object submitted for tests has been manufactured in accordance with the following drawing and documents. KEMA has verified that these drawing and documents adequately represent the object tested. The manufacturer is responsible for the correctness of these drawing and documents and the technical data presented.

The following drawing and documents have been included in this Report:

| Drawing No./document No. | Revision |
|---|---|
| GTSPL/K01/06/14 | 00 |

The following document is only listed for reference and is kept in KEMA's files:

| Document no. | Revision/date |
|---|---|
| Components list GTM/OXAS/1233A | - |
| Jointing instruction GTM/XAS/31115 | - |

## 2 GENERAL INFORMATION

### 2.1 The tests were witnessed by

| Name | Company |
|---|---|
| Mr Gurubax Singh | Gala Shrink Fit, |
| 12 to 15 August 2014 | Mumbai, India |

### 2.2 The tests were carried out by

| Name | Company |
|---|---|
| Ms H. He | KEMA Nederland B.V., |
| Mr A. Sengers | Arnhem, The Netherlands |
| Mr T. Ariaans | |
| Mr E. Pultrum | |
| Mr D. Bouchier | |
| Mr N. Dobbe | |
| Mr K. Linden | |

### 2.3 Measurement uncertainty

A table with measurement uncertainties is enclosed in this report. Unless otherwise stated, the measurement uncertainties of the results presented in this report are as indicated in that table.

# 3 TEST SEQUENCE 1.1 FOR OUTDOOR TERMINATION (TWO TERMINATIONS)

## 3.1 Determination of the cable conductor temperature

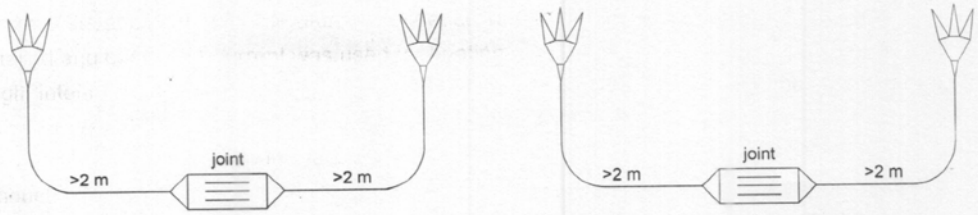
### 3.1.1 Determination of the cable conductor temperature

**Standard**

Standard IEC 60840, Annex A, Subclause A.3.1 was used as a guide

For the tests at elevated temperature, a reference loop for temperature control of the conductor was installed and conductor current was used for heating. The reference cable was cut from the total cable length intended for the type test. This reference loop was installed close to the main loop in order to create the same environmental conditions as for the test loop.
The heating currents in both the reference loop and the test loop were kept equal at all times, thus the conductor temperature of the reference loop is representative for the conductor temperature of the test loop. IEC 60840, Annex A was used as a guide and IEC 60840, Subclause A.3.1, method 1 was applied.

The tests at elevated temperature are carried out after the conductor temperature has been within the stated temperature limits for at least 2 hours. The test set-up was consisting of a joint as part of a cable system, also incorporating two outdoor terminations which are not part of the type test objects. The test set-up of two separate main test loops connected in series.




Sample 1 and 2 for test sequence 1.1

## 3.3 DC voltage dry

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 1 |
| Test date | 12 August 2014 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 21 | °C |
| Temperature of test object | 21 | °C |

| Testing arrangement | | Voltage applied, DC | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 1 | Metal screens | 6 | 38 | 15 |
| Conductor 1,2 and 3 of test loop 2 | Metal screens | 6 | 38 | 15 |

**Note**

On request of the client the test has been performed more severely at 6 x $U_0$ instead of 4 x $U_0$.

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 3.4 AC voltage dry

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 1 |
| Test date | 12 August 2014 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 21 | °C |
| Temperature of test object | 22 | °C |

| Testing arrangement | | Voltage applied, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 1 | Metal screens | 4,5 | 28,5 | 5 |
| Conductor 1,2 and 3 of test loop 2 | Metal screens | 4,5 | 28,5 | 5 |

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 3.5 AC voltage wet

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 1 |
| Test date | 13 August 2014 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 22 | °C |

**Characteristic test data**

| | | |
|---|---|---|
| Temperature of test object | 22 | °C |
| Temperature of water | 22 | °C |
| Vertical component | 1,4 | mm/min |
| Horizontal component | 1,9 | mm/min |
| Pre-wetting period | > 15 | min |

| Testing arrangement | | Voltage applied, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 1 | Metal screens | 4 | 25,5 | 1 |
| Conductor 1,2 and 3 of test loop 2 | Metal screens | 4 | 25,5 | 1 |

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 3.6 Partial discharge at ambient temperature

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 2 |
| Test date | 13 August 2014 |

**Environmental conditions**

| | |
|---|---|
| Ambient temperature | 22 °C |

**Characteristic test data**

| | |
|---|---|
| Temperature of test object | 22 °C |
| Circuit | direct |
| Calibration | 5 pC |
| Noise level at 1,73 $U_0$ | 2.5 pC |
| Declared sensitivity | 5 pC |
| Required sensitivity | ≤ 5 pC |
| Centre frequency | 117,5 kHz |
| Bandwidth (Δf) | 100 kHz |
| Test frequency | 50 Hz |
| Coupling capacitor | 2600 pF |

| Core | Voltage applied, 50 Hz | | Duration | Partial discharge level |
|---|---|---|---|---|
| | ... x $U_0$ | (kV) | (s) | (pC) |
| 1 of test loop 1 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 2 of test loop 1 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 3 of test loop 1 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 1 of test loop 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 2 of test loop 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 3 of test loop 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |

**Requirement**

The maximum partial discharge level from the test object at 1,73 $U_0$ shall not exceed 10 pC.

**Result**

The object passed the test.

## 3.7 Impulse voltage at elevated temperature

**Standard and date**

Standard IEC 60502-4, Table 5, test number 3
Test date 26 August 2014

**Environmental conditions**

Ambient temperature 21 °C

**Characteristic test data**

Temperature of test object 97 °C
Specified test voltage 95 kV

| Testing arrangement | | Polarity | Voltage applied | No. of impulses | See figure on next pages |
|---|---|---|---|---|---|
| Voltage applied to | Earthed | | (% of test voltage) | | |
| Conductor 1 test loop 1 and 2 | Metal screens and conductor 2 and 3 | Positive | 50 | 1 | 1 (waveshape) |
| | | | 65 | 1 | 2 |
| | | | 80 | 1 | 2 |
| | | | 100 | 10 | 3 and 4 |
| Conductor 1 test loop 1 and 2 | Metal screens and conductor 2 and 3 | Negative | 50 | 1 | 5 (waveshape) |
| | | | 65 | 1 | 6 |
| | | | 80 | 1 | 6 |
| | | | 100 | 10 | 7 and 8 |
| Conductor 2 test loop 1 and 2 | Metal screens and conductor 1 and 3 | Positive | 50 | 1 | 9 (waveshape) |
| | | | 65 | 1 | 10 |
| | | | 80 | 1 | 10 |
| | | | 100 | 10 | 11 and 12 |
| Conductor 2 test loop 1 and 2 | Metal screens and conductor 1 and 3 | Negative | 50 | 1 | 13(waveshape) |
| | | | 65 | 1 | 14 |
| | | | 80 | 1 | 14 |
| | | | 100 | 10 | 15 and 16 |
| Conductor 3 test loop 1 and 2 | Metal screens and conductor 1 and 2 | Positive | 50 | 1 | 17 (waveshape) |
| | | | 65 | 1 | 18 |
| | | | 80 | 1 | 18 |
| | | | 100 | 10 | 19 and 20 |
| Conductor 3 test loop 1 and 2 | Metal screens and conductor 1 and 2 | Negative | 50 | 1 | 21 (waveshape) |
| | | | 65 | 1 | 22 |
| | | | 80 | 1 | 22 |
| | | | 100 | 10 | 23 and 24 |

**Note**

On request of the client the applied LI voltage was 95 kV instead of 75 kV.

**Requirement**

Each core of the cable and accessory shall withstand without failure 10 positive and 10 negative voltage impulses.

**Result**

The object passed the test.

## 3.8 Heating cycle voltage in air

**Standard and date**

Standard IEC 60502-4, Table 5, test number 4
Test dates 28 August to 9 October 2014

**Environmental conditions**

Ambient temperature 20-22 °C

**Characteristic test data**

Heating method conductor current
Stabilized temperature 97 °C

| No. of heating cycles | Required steady conductor temperature (°C) | Heating current during steady condition (A) | Heating cycle | | | Voltage | |
|---|---|---|---|---|---|---|---|
| | | | Heating | | Cooling | | |
| | | | Total duration (h) | Duration of conductor at steady temperature (h) | Total duration (h) | Total duration (h) | Voltage applied 2,5 $U_0$ (kV) |
| 126 | 95-100 | approx. 409 | 5 | 2 | 4 | 9 | 16 |

**Note**

On request of the client the applied number of heating cycles was 126 instead of 60.

**Requirement**

No breakdown shall occur.

**Result**

The object passed the test.

## 3.9 Immersion

**Standard and date**

Standard IEC 60502-4, Table 5, test number 5
Test dates 4 to 8 November 2014

**Environmental conditions**

Ambient temperature 20-22 °C

**Characteristic test data**

Heating method conductor current
Stabilized temperature 97 °C
Height above every part of the termination 0,03-0,05 m

| No. of heating cycles | Required steady conductor temperature (°C) | Heating current during steady condition (A) | Heating cycle | | |
|---|---|---|---|---|---|
| | | | Heating | | Cooling |
| | | | Total duration (h) | Duration of conductor at steady temperature (h) | Total duration (h) |
| 10 | 95 - 100 | approx. 413 | 5 | 2 | 4 |

**Requirement**

The test shall be carried out successfully.

**Result**

The object passed the test.

## 3.10 Partial discharge at elevated and ambient temperature

### 3.10.1 Partial discharge at elevated temperature

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 6 |
| Test date | 11 November 2014 |

**Environmental conditions**

| | |
|---|---|
| Ambient temperature | 20 °C |

**Characteristic test data**

| | |
|---|---|
| Temperature of test object | 97 °C |
| Circuit | direct |
| Calibration | 5 pC |
| Noise level at 1,73 $U_0$ | 2 pC |
| Declared sensitivity | 4 pC |
| Required sensitivity | ≤ 5 pC |
| Centre frequency | 98 kHz |
| Bandwidth (Δf) | 100 kHz |
| Test frequency | 50 Hz |
| Coupling capacitor | 2600 pF |

| Core | Voltage applied, 50 Hz | | Duration | Partial discharge level |
|---|---|---|---|---|
| | ... x $U_0$ | (kV) | (s) | (pC) |
| 1 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 2 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 3 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |

**Requirement**

The maximum partial discharge level from the test object at 1,73 $U_0$ shall not exceed 10 pC.

**Result**

The object passed the test.

### 3.10.2 Partial discharge at ambient temperature

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 6 |
| Test date | 13 November 2014 |

**Environmental conditions**

| | |
|---|---|
| Ambient temperature | 20 °C |

**Characteristic test data**

| | |
|---|---|
| Temperature of test object | 20 °C |
| Circuit | direct |
| Calibration | 5 pC |
| Noise level at 1,73 $U_0$ | 2,5 pC |
| Declared sensitivity | 5 pC |
| Required sensitivity | ≤ 5 pC |
| Centre frequency | 124,5 kHz |
| Bandwidth (Δf) | 100 kHz |
| Test frequency | 50 Hz |
| Coupling capacitor | 2600 pF |

| Core | Voltage applied, 50 Hz | | Duration | Partial discharge level |
|---|---|---|---|---|
| | ... x $U_0$ | (kV) | (s) | (pC) |
| 1 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 2 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |
| 3 of test loop 1 and 2 | 2 | 12,5 | 10 | - |
| | 1,73 | 11 | - | Not detectable |

**Requirement**

The maximum partial discharge level from the test object at 1,73 $U_0$ shall not exceed 10 pC.

**Result**

The object passed the test.

## 3.11 Impulse voltage at ambient temperature

**Standard and date**

Standard IEC 60502-4, Table 5, test number 10
Test date 14 November 2014

**Environmental conditions**

Ambient temperature 20 °C

**Characteristic test data**

Temperature of test object 20 °C
Specified test voltage 95 kV

| Testing arrangement | | Polarity | Voltage applied | No. of impulses | See figure on next pages |
|---|---|---|---|---|---|
| Voltage applied to | Earthed | | (% of test voltage) | | |
| Conductor 1 of test loop 1 and 2 | Metal screens and conductor 2 and 3 | Positive | 50 | 1 | 1 (waveshape) |
| | | | 65 | 1 | 2 |
| | | | 80 | 1 | 2 |
| | | | 100 | 10 | 3 and 4 |
| Conductor 1 of test loop 1 and 2 | Metal screens and conductor 2 and 3 | Negative | 50 | 1 | 5 (waveshape) |
| | | | 65 | 1 | 6 |
| | | | 80 | 1 | 6 |
| | | | 100 | 10 | 7 and 8 |
| Conductor 2 of test loop 1 and 2 | Metal screens and conductor 1 and 3 | Positive | 50 | 1 | 9 (waveshape) |
| | | | 65 | 1 | 10 |
| | | | 80 | 1 | 10 |
| | | | 100 | 10 | 11 and 12 |
| Conductor 2 of test loop 1 and 2 | Metal screens and conductor 1 and 3 | Negative | 50 | 1 | 13 (waveshape) |
| | | | 65 | 1 | 14 |
| | | | 80 | 1 | 14 |
| | | | 100 | 10 | 15 and 16 |
| Conductor 3 of test loop 1 and 2 | Metal screens and conductor 1 and 2 | Positive | 50 | 1 | 17(waveshape) |
| | | | 65 | 1 | 18 |
| | | | 80 | 1 | 18 |
| | | | 100 | 10 | 19 and 20 |
| Conductor 3 of test loop 1 and 2 | Metal screens and conductor 1 and 2 | Negative | 50 | 1 | 21 (waveshape) |
| | | | 65 | 1 | 22 |
| | | | 80 | 1 | 22 |
| | | | 100 | 10 | 23 and 24 |

**Note**

On request of the client the applied LI voltage was 95 kV instead of 75 kV.

**Requirement**

Each core of the cable and accessory shall withstand without failure 10 positive and 10 negative voltage impulses.

**Result**

The object passed the test.

## 3.12 AC voltage dry

**Standard and date**

Standard IEC 60502-4, Table 5, test number 11
Test date 17 November 2014

**Environmental conditions**

Ambient temperature 20 °C
Temperature of test object 20 °C

| Testing arrangement | | Voltage applied, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 1 and 2 | Metal screens | 2,5 | 16 | 15 |

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 3.13 Examination

**Standard and date**

| | |
|---|---|
| Standard | IS 13573 (part 2), table 2, test xiv) |
| Test date | 1 December 2014 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 21 | °C |
| Temperature of test object | 21 | °C |

| Test loop | Observations[1)] |
|---|---|
| 1 and 2 | None of the following has been detected:<br>- cracking in the filling material and/or tape or tubing components<br>- a moisture path bridging a primary seal<br>- corrosion and/or tracking and/or erosion<br>- leakage of any insulating material |
| 1) Photographs of the examination are presented on the next page | |

**Result**

The results are for information only.

# 4 TEST SEQUENCE 1.2 FOR OUTDOOR TERMINATION (ONE TERMINATION)

## 4.1 Test arrangement

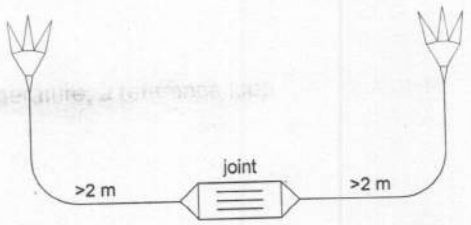
### 4.1.1 Determination of the cable conductor temperature

**Standard**

Standard IEC 60840, Annex A, Subclause A.3.1 was used as a guide

For the tests at elevated temperature, a reference loop for temperature control of the conductor was installed and conductor current was used for heating. The reference cable was cut from the total cable length intended for the type test. This reference loop was installed close to the main loop in order to create the same environmental conditions as for the test loop.
The heating currents in both the reference loop and the test loop were kept equal at all times, thus the conductor temperature of the reference loop is representative for the conductor temperature of the test loop. IEC 60840, Annex A was used as a guide and IEC 60840, Subclause A.3.1, method 1 was applied.

The tests at elevated temperature are carried out after the conductor temperature has been within the stated temperature limits for at least 2 hours. The test set-up was consisting of a joint as part of a cable system, also incorporating a heat-shrinkable outdoor termination and a heat-shrinkable indoor termination.




Sample 3 for test sequence 1.2

## 4.2 DC voltage dry

**Standard and date**

Standard IEC 60502-4, Table 5, test number 1
Test date 12 August 2014

**Environmental conditions**

Ambient temperature 21 °C
Temperature of test object 22 °C

| Testing arrangement | | Voltage applied, DC | | Duration (min) |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | |
| Conductor 1,2 and 3 of test loop 3 | Metal screens | 6 | 38 | 15 |

**Note**

On request of the client the test has been performed more severely at 6 x $U_0$ instead of 4 x $U_0$.

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 4.3 AC voltage dry

**Standard and date**

Standard IEC 60502-4, Table 5, test number 1
Test date 12 August 2014

**Environmental conditions**

Ambient temperature 21 °C
Temperature of test object 22 °C

| Testing arrangement | | Voltage applied, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 3 | Metal screens and conductor 2 and 3 | 4,5 | 28,5 | 5 |

**Note**

The test was more severe than the requirement; both the DC voltage test and the AC voltage test is conducted.

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 4.4 Thermal short circuit test (screen)

**Standard and date**

Standard IEC 60502-4, Table 5, test number 7
Test date 9 January 2015

**Environmental conditions**

Ambient temperature 22 °C

**Characteristic test data**

Stabilized conductor temperature 97 °C

| **Conductor heating** | | |
|---|---|---|
| Required conductor temperature θ (°C) | Applied 3-phase heating current (A) | Conductor stable at 97 °C before short-circuit application (h) |
| $95 \leq \theta \leq 100$ | 530 | 2 |

| **Short-circuit application on screen (see figures on the next pages)** | | | |
|---|---|---|---|
| Specified short-circuit current (kA) | Frequency (Hz) | Duration (s) | Number of short-circuit applications |
| 2,5 | 50 | 1 | 2 |

**Procedure**

The conductor temperature shall be maintained within the stated temperature limits for at least 2 h before carrying out the short-circuit test. Between the two short-circuit applications, the cable screen shall be allowed to cool down to a temperature less than 10 K above its temperature prior to the first short-circuit application.

**Requirement**

No visible deterioration may occur.

**Result**

The object passed the test.

## 4.5 Thermal short circuit test (conductor)

| | |
|---|---|
| Standard and date | |
| Standard | IEC 60502-4, Table 5, test number 8 |
| Test date | 28 January 2015 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 11 | °C |

**Characteristic test data**

| | | |
|---|---|---|
| Conductor material | | Aluminum |
| Cross section conductor | 185 | $mm^2$ |
| Maximum short circuit conductor temperature | 250 | °C |

**First short circuit application**

| | | |
|---|---|---|
| Start temperature of test object (measured value) | 13,5 | °C |
| Selected duration of short circuit current | 1 | s |
| Calculated short circuit current | 22,5 | kA |
| Thermal current, three phase | 22,7 | kA |
| Duration | 1,06 | s |

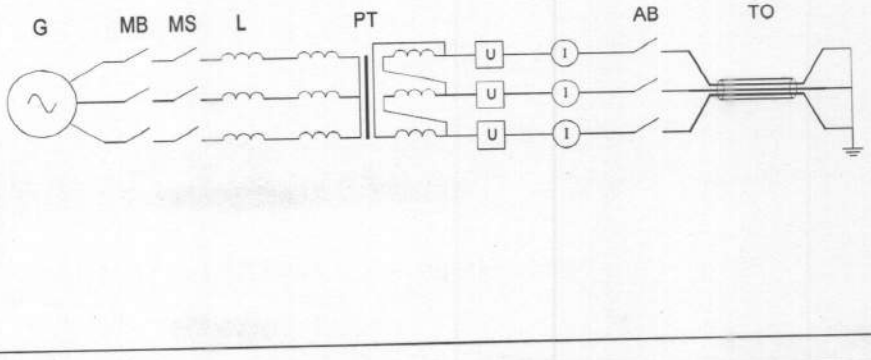
**Second short circuit application**

| | | |
|---|---|---|
| Start temperature of test object (measured value) | 13,5 | °C |
| Selected duration of short circuit current | 1 | s |
| Calculated short circuit current | 22,5 | kA |
| Thermal current, three phase | 22,7 | kA |
| Duration | 1,05 | s |

**Procedure**

Two short-circuits shall be applied to raise the conductor temperature to the maximum permissible short-circuit temperature of the cable within 5 s. Between the two short-circuits, the test loop shall be allowed to cool to a temperature less than 10 K above its temperature prior to the first short-circuit.

## 4.6 Test circuit S01



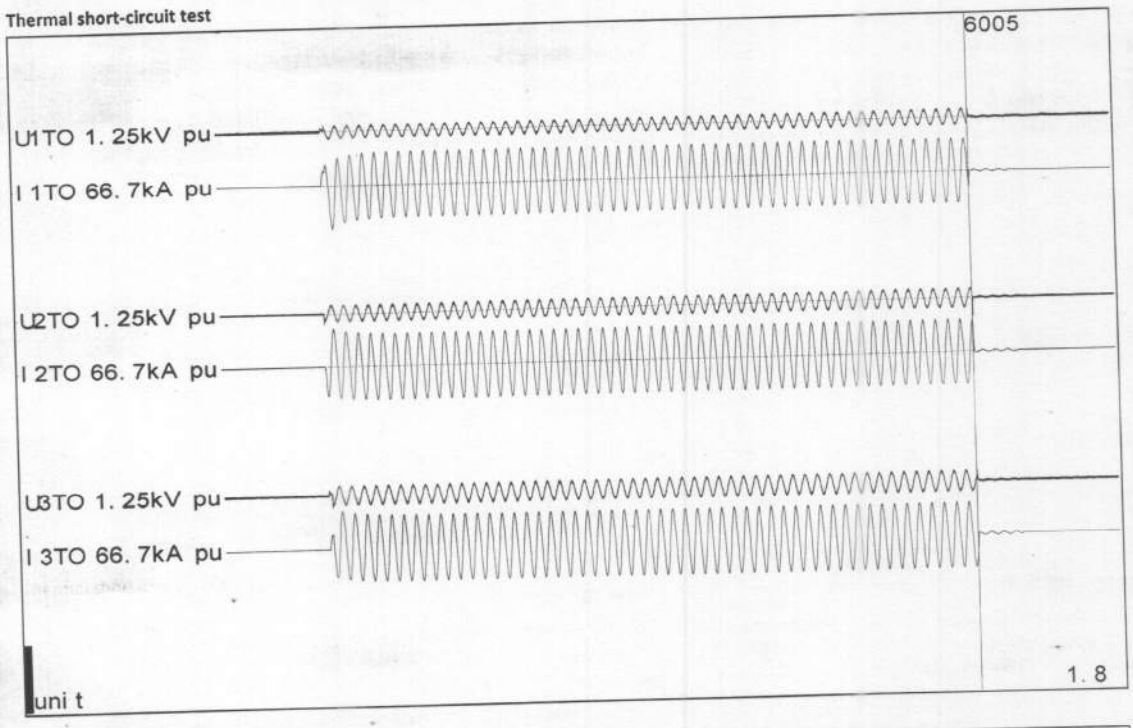

| | | | | | |
|---|---|---|---|---|---|
| G | = Generator | TO | = Test Object | U | = Voltage Measurement to earth |
| MB | = Master Breaker | L | = Reactor | I | = Current Measurement |
| MS | = Make Switch | | | | |
| PT | = Power Transformer | | | | |

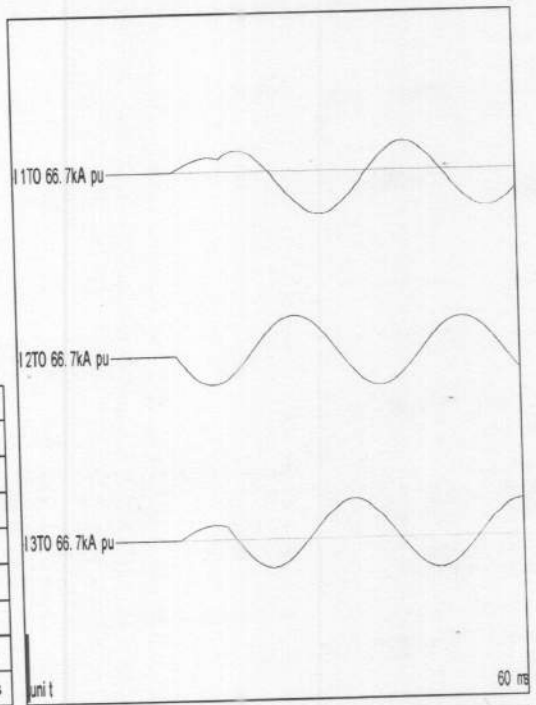
| Supply | | |
|---|---|---|
| Power | MVA | 47,2 |
| Frequency | Hz | 50 |
| Phase(s) | | 3 |
| Voltage | kV | 2,2 |
| Current | kA | 22 |
| Impedance | Ω | 0,033 |
| Power factor | | < 0,1 |
| Neutral | | Not earthed |

| Load | |
|---|---|
| Short-circuit point | earthed |

## 4.7 Test results and oscillograms

**Thermal short-circuit test**




**Test number:** **150128-6005**

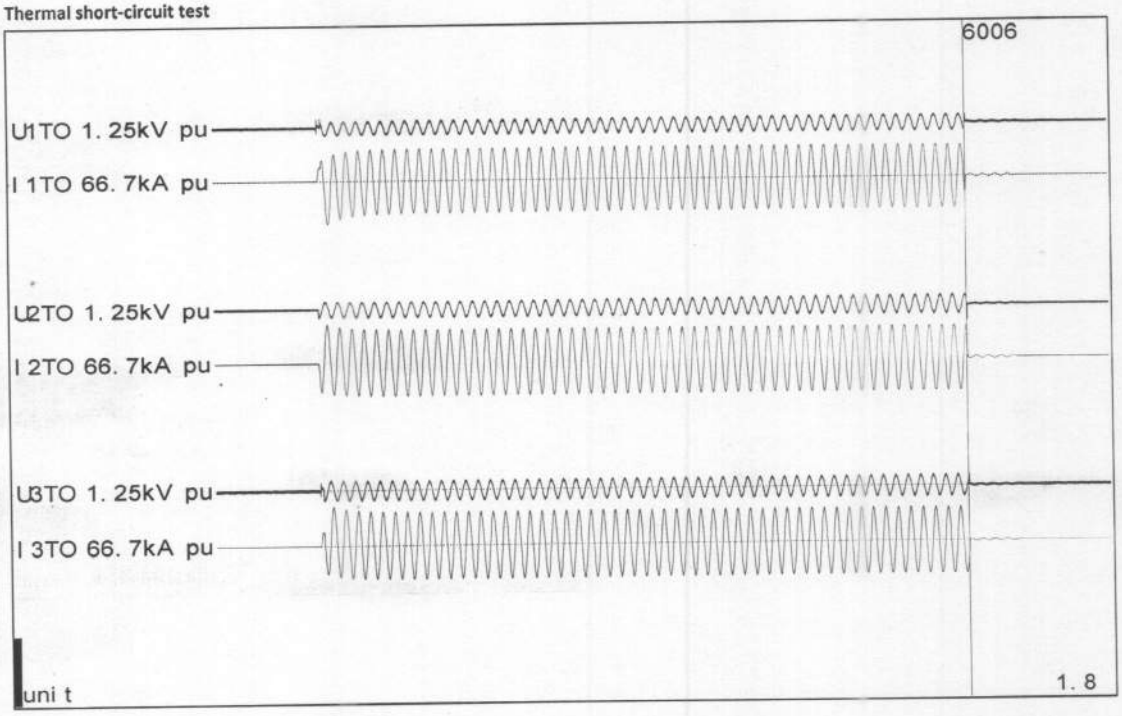
| Phase | | - | - | - |
|---|---|---|---|---|
| Peak value of current | kA | -42,6 | 38,7 | 38,1 |
| Symmetrical current, beginning | kA | 23,0 | 23,5 | 23,3 |
| Symmetrical current, middle | kA | 22,7 | 23,1 | 22,8 |
| Symmetrical current, end | kA | 22,5 | 22,9 | 22,7 |
| Symmetrical current, average | kA | 22,8 | 23,3 | 22,1 |
| Average current, three phase | kA | 22,7 | | |
| Current duration | s | 1,05 | 1,05 | 1,05 |
| Thermal equivalent | | 22,5 kA during 1,06 s | | |

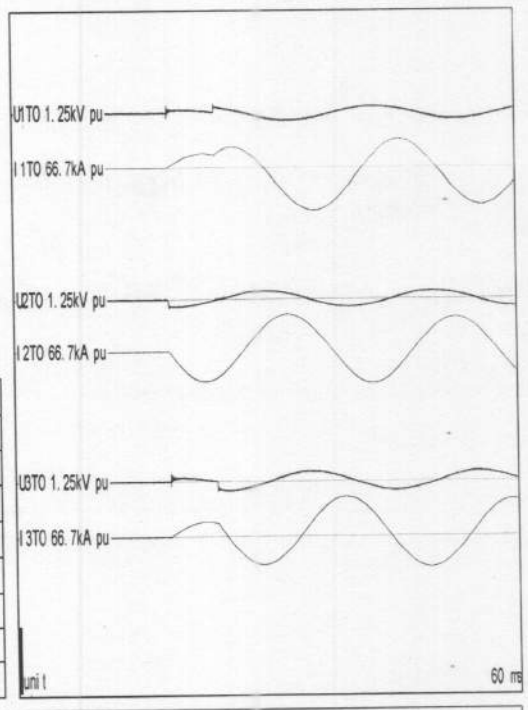
Ambient temperature 13,5 °C

Remarks:

Version: 1

**Thermal short-circuit test**




**Test number:** **150128-6006**

| Phase | | - | - | - |
|---|---|---|---|---|
| Peak value of current | kA | -42,3 | 38,6 | 37,9 |
| Symmetrical current, beginning | kA | 23,0 | 23,4 | 23,2 |
| Symmetrical current, middle | kA | 22,6 | 23,0 | 22,7 |
| Symmetrical current, end | kA | 22,5 | 22,9 | 22,6 |
| Symmetrical current, average | kA | 22,8 | 23,2 | 22,0 |
| Average current, three phase | kA | 22,7 | | |
| Current duration | s | 1,05 | 1,05 | 1,05 |
| Thermal equivalent | | 22,5 kA during 1,10 s | | |

Ambient temperature 13,5 °C

Remarks:

Version: 1

## 4.8 Condition / inspection after test

**Requirement**

No visible deterioration may occur.

**Result**

No visible change. No visible damage.
The object passed the test.

## 4.9 Impulse voltage at ambient temperature

**Standard and date**

Standard IEC 60502-4, Table 5, test number 10
Test date 29 January 2015

**Environmental conditions**

Ambient temperature 20 °C

**Characteristic test data**

Temperature of test object 20 °C
Specified test voltage 95 kV

| Testing arrangement | | Polarity | Voltage applied (% of test voltage) | No. of impulses | See figure on next pages |
|---|---|---|---|---|---|
| Voltage applied to | Earthed | | | | |
| Conductor 1 test loop 3 | Metal screens and conductor 2 and 3 | Positive | 50 | 1 | 1 (waveshape) |
| | | | 65 | 1 | 2 |
| | | | 80 | 1 | 2 |
| | | | 100 | 10 | 3 and 4 |
| Conductor 1 test loop 3 | Metal screens and conductor 2 and 3 | Negative | 50 | 1 | 5 (waveshape) |
| | | | 65 | 1 | 6 |
| | | | 80 | 1 | 6 |
| | | | 100 | 10 | 7 and 8 |
| Conductor 2 test loop 3 | Metal screens and conductor 1 and 3 | Positive | 50 | 1 | 9 (waveshape) |
| | | | 65 | 1 | 10 |
| | | | 80 | 1 | 10 |
| | | | 100 | 10 | 11 and 12 |
| Conductor 2 test loop 3 | Metal screens and conductor 1 and 3 | Negative | 50 | 1 | 13 (waveshape) |
| | | | 65 | 1 | 14 |
| | | | 80 | 1 | 14 |
| | | | 100 | 10 | 15 and 16 |
| Conductor 3 test loop 3 | Metal screens and conductor 1 and 2 | Positive | 50 | 1 | 17(waveshape) |
| | | | 65 | 1 | 18 |
| | | | 80 | 1 | 18 |
| | | | 100 | 10 | 19 and 20 |
| Conductor 3 test loop 3 | Metal screens and conductor 1 and 2 | Negative | 50 | 1 | 21 (waveshape) |
| | | | 65 | 1 | 22 |
| | | | 80 | 1 | 22 |
| | | | 100 | 10 | 23 and 24 |

**Note**

On request of the client the applied LI voltage was 95 kV instead of 75 kV.

**Requirement**

Each core of the cable and accessory shall withstand without failure 10 positive and 10 negative voltage impulses.

**Result**

The object passed the test.

## 4.10 AC voltage dry

**Standard and date**

| | |
|---|---|
| Standard | IEC 60502-4, Table 5, test number 11 |
| Test date | 29 January 2015 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 20 | °C |
| Temperature of test object | 20 | °C |

| Testing arrangement | | Voltage applied, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to | Earth connected to | ... x $U_0$ | (kV) | (min) |
| Conductor 1,2 and 3 of test loop 3 | Metal screens | 2,5 | 16 | 15 |

**Requirement**

No breakdown or flashover shall occur.

**Result**

The object passed the test.

## 4.11 Examination

**Standard and date**

| | |
|---|---|
| Standard | IS 13573 (part 2), table 2, test xiv) |
| Test date | 5 February 2015 |

**Environmental conditions**

| | | |
|---|---|---|
| Ambient temperature | 20 | °C |
| Temperature of test object | 20 | °C |

| Test loop | Observations[1)] |
|---|---|
| 3 | None of the following has been detected:<br>- cracking in the filling media and/or tape or tube components<br>- a moisture path across a primary seal<br>- corrosion and/or tracking and/or erosion<br>- leakage of any insulating material |
| 1) Photographs of the examination are presented on the next page | |

**Result**

The results are for information only.

# 5 TEST SEQUENCE 1.5 (ONE OUTDOOR TERMINATION)

## 5.1 Salt fog

**Standard and date**

Standard IEC 60502-4, Table 5, test number 13
Test dates 11 February to 23 March 2015

**Environmental conditions**

Ambient temperature 20-22 °C
Temperature of test object 20-22 °C

**Characteristic test data**

Leakage current protection ($I_{max}$) 1 ± 0,1 A
Conductivity 1600 ± 200 mS/m
Rate of flow 0,4 ± 1 l/h/m$^3$

| Testing arrangement | | Applied Voltage, 50 Hz | | Duration |
|---|---|---|---|---|
| Voltage applied to conductor | Earth connected to | ... x $U_0$ | (kV) | (h) |
| 1, 2 and 3 | Metallic screen | 1,25 | 8 | 1000 |

**Requirement**

No breakdown or flashover, no more than 3 trips, no substantial damage of the insulation shall occur.

**Result**

There was no breakdown or flashover, no trips.
After the salt fog test, loss of dielectric quality due to tracking and/or erosion was found on one of the three phases.

## 5.2 Examination

**Standard and date**

Standard IS 13573 (part 2), table 2, test xiv)
Test date 23 March 2015

**Environmental conditions**

Ambient temperature 20 °C

**Characteristic test data**

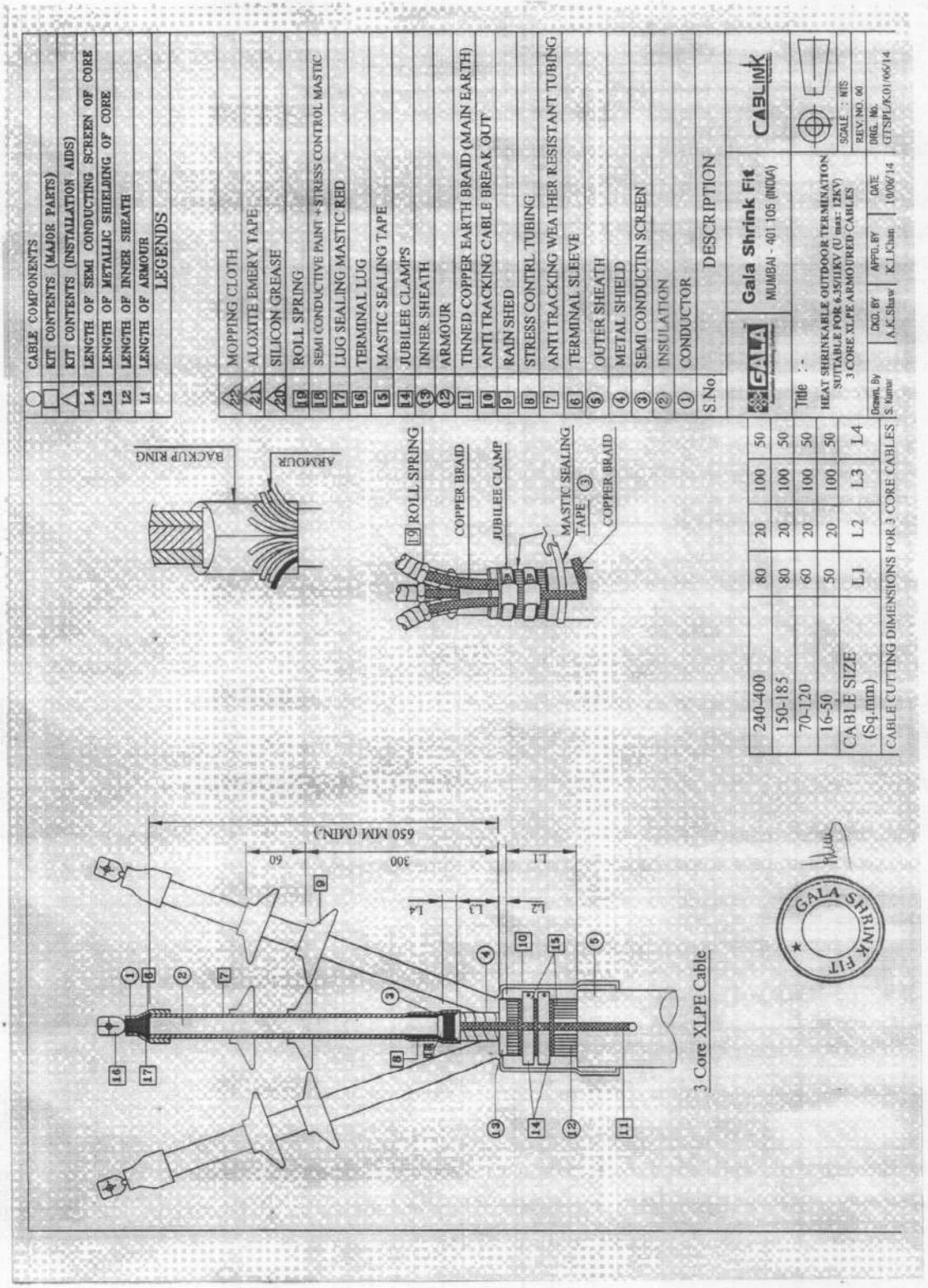
Temperature of test object 20 °C

| Object | Observations |
|---|---|
| Test loop 4 | None of the following has been detected:<br>- cracking in the filling media and/or tape or tube components<br>- a moisture path across a primary seal<br>- corrosion and/or tracking and/or erosion<br>- leakage of any insulating material |

**Result**

For information only.

## 6 DRAWING


CABLE COMPONENTS
KIT CONTENTS (MAJOR PARTS)
KIT CONTENTS (INSTALLATION AIDS)
L4 LENGTH OF SEMI CONDUCTING SCREEN OF CORE
L3 LENGTH OF METALLIC SHIELDING OF CORE
L2 LENGTH OF INNER SHEATH
L1 LENGTH OF ARMOUR
LEGENDS
MOPPING CLOTH
ALOXITE EMERY TAPE
SILICON GREASE
ROLL SPRING
SEMI CONDUCTIVE PAINT + STRESS CONTROL MASTIC
LUG SEALING MASTIC RED
TERMINAL LUG
MASTIC SEALING TAPE
JUBILEE CLAMPS
INNER SHEATH
ARMOUR
TINNED COPPER EARTH BRAID (MAIN EARTH)
ANTI TRACKING CABLE BREAK OUT
RAIN SHED
STRESS CONTRL TUBING
ANTI TRACKING WEATHER RESISTANT TUBING
TERMINAL SLEEVE
OUTER SHEATH
METAL SHIELD
SEMI CONDUCTIN SCREEN
INSULATION
CONDUCTOR
S.No
DESCRIPTION
GALA
Gala Shrink Fit
MUMBAI - 401 105 (INDIA)
CABLINK
Title :-
HEAT SHRINKABLE OUTDOOR TERMINATION
SUITABLE FOR 6.35/11KV (U max: 12KV)
3 CORE XLPE ARMOURED CABLES
SCALE : NTS
REV. NO. 00
DRG. No.
GTSPL/K01/06/14
Drawn. By S. Kumar
CKD. BY A.K.Shaw
APPD. BY K.I.Khan
DATE 10/06/14
BACKUP RING
ARMOUR
ROLL SPRING
COPPER BRAID
JUBILEE CLAMP
MASTIC SEALING TAPE
COPPER BRAID
650 MM (MIN.)
300
60
L1
L2
L3
L4
3 Core XLPE Cable
GALA SHRINK FIT
CABLE CUTTING DIMENSIONS FOR 3 CORE CABLES
CABLE SIZE (Sq.mm)
L1
L2
L3
L4
240-400 80 20 100 50
150-185 80 20 100 50
70-120 60 20 100 50
16-50 50 20 100 50

## 7 MEASUREMENT UNCERTAINTY

The measurement uncertainties in the results presented are as specified below unless otherwise indicated.

| Measurement | Measurement uncertainty |
|---|---|
| Dielectric tests and impulse current tests: | |
| – peak value | ≤ 3% |
| – time parameters | ≤ 10% |
| Capacitance measurement | 0,3% |
| Tan δ measurement | ± 0,5% ± 5 x $10^{-5}$ |
| Partial discharge measurement: | |
| – < 10 pC | 2 pC |
| – 10 to 100 pC | 5 pC |
| – > 100 pC | 20% |
| Measurement of impedance AC-resistance measurement | ≤ 1% |
| Measurement of losses | ≤ 1% |
| Measurement of insulation resistance | ≤ 10% |
| Measurement of DC resistance: | |
| – 1 to 5 μΩ | 1% |
| – 5 to 10 μΩ | 0,5% |
| – 10 to 200 μΩ | 0,2% |
| Radio interference test | 2 dB |
| Calibration of current transformers | 2,2 x $10^{-4}$ $I_i/I_u$ and 290 μrad |
| Calibration of voltage transformers | 1,6 x $10^{-4}$ $U_i/U_u$ and 510 μrad |
| Measurement of conductivity | 5% |
| Measurement of temperature: | |
| – -50 to -40 °C | 3 K |
| – -40 to125 °C | 2 K |
| – 125 to 150 °C | 3 K |
| Tensile test | 1% |
| Sound level measurement | type 1 meter as per IEC 60651 and ANSI S1,4,1971 |
| Measurement of voltage ratio | 0,1% |